

THE YANKEE STORY



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Yankee Atomic Electric Company

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<i>Vice-President</i>	Charles F. Avila	Boston, Massachusetts
<i>Vice-President</i>	Howard J. Cadwell	West Springfield, Massachusetts
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Robert F. Krause	<i>New England Electric System Boston, Massachusetts</i>
Guido R. Perera	<i>Eastern Utilities Associates Boston, Massachusetts</i>
John F. Rich	<i>New England Gas & Electric Assoc. Cambridge, Massachusetts</i>
Avery R. Schiller	<i>Public Service Co. of New Hampshire Manchester, New Hampshire</i>
Olcott D. Smith, Esq.	<i>Aetna Life Affiliated Companies Hartford, Connecticut</i>
William Webster	<i>New England Electric System Boston, Massachusetts</i>

During the formative years of the Yankee project notable contributions were made by former directors Austin D. Barney of the Hartford Electric Light Co., Irwin L. Moore, New England Electric System; and former directors now deceased, Floyd D. Campbell of New England Gas & Electric Association; Thomas G. Dignan, Boston Edison Company; William F. Wyman, Central Maine Power Company and Ralph D. Booth, Jackson & Moreland, Inc.

The Yankee Philosophy

These basic reasons for building and operating the Yankee plant have been expressed by President William Webster during his many talks on Yankee:



“One of the prime reasons was that it was expected of us. Electric utilities recognize that it is their obligation to their customers and stockholders to seek out and to provide the most efficient and economical service. As long as there was a possibility that we might be able to bring competitive power to New England through the atom, it was properly expected that we attempt it.”



“We felt that here was a job for private enterprise and industry, not the government. Call this the old Yankee pioneering spirit, if you will.”



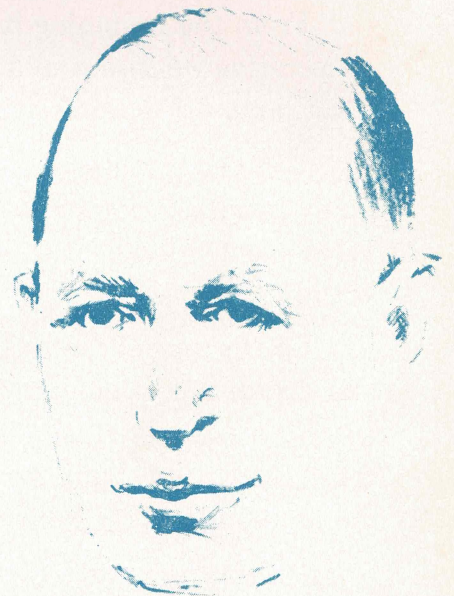
“We realized that we had much to learn and that there would be no substitute for first-hand experience in an atomic power plant. There seemed little to gain by waiting. Here was an opportunity to build a cadre of personnel who would know the atomic power field and could grow with it in the future.”



“In the event of a break-through in technology, in competitive power costs, or in the value of plutonium or radio-isotopic by-products, the owner of a full-scale plant in actual operation would be in the best position to benefit.”



“We knew that the presence of a full-scale plant in New England could focus attention on the atomic field in this region and could attract allied industries which might grow and gain business as the atomic power industry expanded over the rest of the nation.”



The Yankee Story

In 1954, President Dwight D. Eisenhower signed the amended Atomic Energy Act which for the first time permitted ownership of atomic facilities by a private company. The following day representatives from a group of New England utilities met and agreed to form a company whose purpose was to build and operate a full-sized plant to utilize atomic energy for the generation of electricity. They recognized that an entirely new and plentiful source of energy was to be found within the atom and that this new method of generating electricity would first become economic in areas such as New England. Here the power from the rivers has already been effectively harnessed, and here coal and oil must be imported from considerable distances.

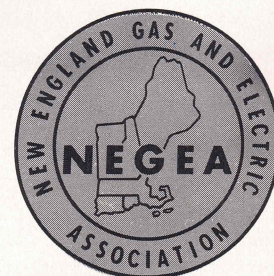
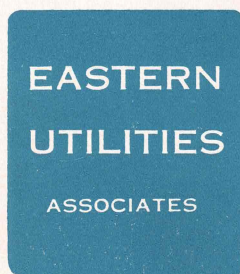
From the beginning it was accepted that a joint effort would provide the best approach. A cooperative venture would give each utility the opportunity for experience with an atomic power plant, and at the same time reduce the investments of the individual companies.

The new company was immediately faced with a number of major decisions. Which of the many possible reactor types would it choose? How big should it be? Where should they locate it? Who should design it — who construct it? Should assistance be requested from the Atomic Energy Commission?

On the type of reactor, Yankee wanted to go forward as soon as possible with the construction and actual operation of a dependable and economically-feasible plant. Thus a pressurized water reactor was selected, similar in principle to the submarine reactors and to the Shippingport reactor then being built for the AEC and the Duquesne Light Company near Pittsburgh. The design developed for Yankee takes full account of the experience gained in these previous reactors and, at the same time, attempts to move in the direction of a more nearly commercialized plant.

As the planning for the Yankee plant progressed, it became evident that a larger size would lead to reduced unit costs for the power produced. What had started out to be a 60-75 thousand-kilowatt plant grew first to 100,000, then to 136,000 and for the second fuel core, to a 160,000-kilowatt rating. It is expected now that the plant's capability will increase to 175,000 net kilowatts.

The location of the plant in Rowe, Massachusetts, was influenced by its geographical loca-



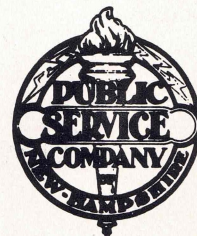
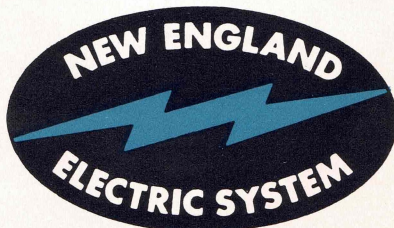
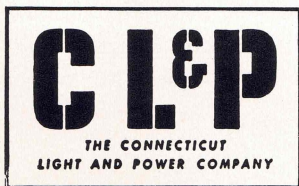
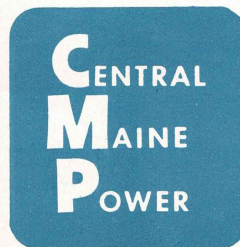
tion, the availability of cooling water from the Deerfield River, existing power transmission facilities, adequate land at a reasonable price, railroad transportation and a favorable public attitude.

Having settled on the type of reactor, it was easy to choose the organizations to perform plant design. Westinghouse Electric Corporation had been intimately connected with all of the previous pressurized water reactors and Stone & Webster Engineering Corporation had assisted in the design of the Shippingport plant. These two companies have been jointly responsible for the engineering design of Yankee, while Stone & Webster has carried out plant construction.

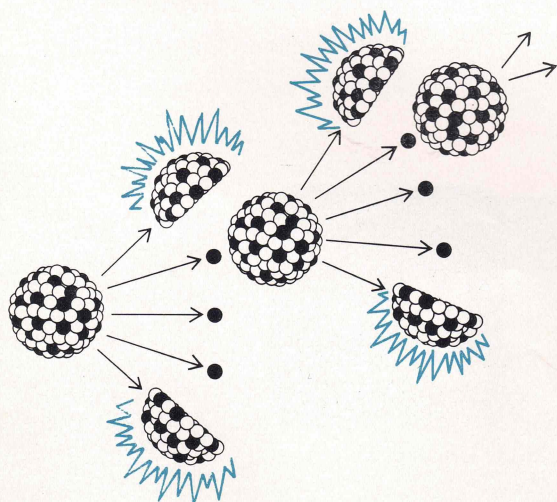
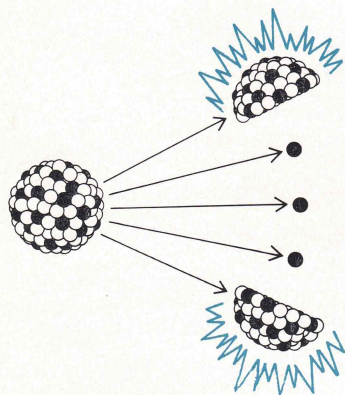
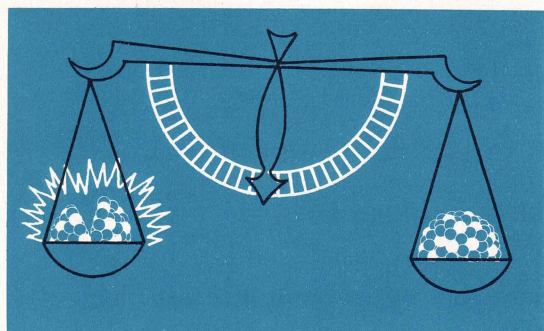
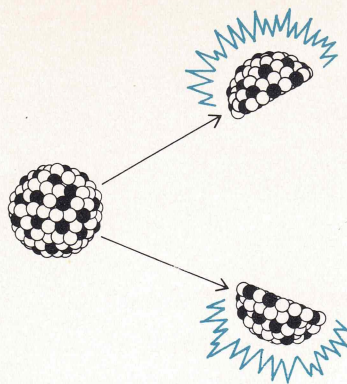
In June of 1956, Yankee signed the first contract of the AEC under its Power Demonstration Reactor Program. This contract provided that the government would assist Yankee by underwriting up to \$5,000,000 of the cost of research and development and by waiving interest charges on the nuclear fuel for a period of five years. The research and development work has been carried out by Westinghouse under a subcontract with Yankee.

The Yankee Atomic Electric Company was formed and incorporated as a Massachusetts electric company and the sponsoring companies arranged the entire financing of the plant. Each of the ten companies, as owners of Yankee, purchased common stock in proportion to its size. This provided about 35 per cent of Yankee's capital needs. An additional 35 per cent came from the sale of Yankee 5 per cent bonds to ten insurance companies and the remaining 30 per cent from unsecured 4¾ per cent notes taken by 28 banks. The total cost of the plant was approximately 43.7 million dollars and the stockholding companies are both owners and customers. All electricity generated at Yankee is purchased by the sponsoring utilities in the same ratio as their stockholdings.

The number of companies involved and the many regulatory requirements necessitated highly impressive and complicated financing. Leading the way in overcoming this difficulty were The Equitable Life Assurance Society of the United States, The First Boston Corporation, and The First National Bank of Boston.



How The Reactor Works



The nuclear heat within the Yankee reactor is developed when atoms of uranium are split apart — that is, fissioned. Each fissioned atom splits into two fragments, each of which becomes an atom in its own right. The significant thing is the fact that these two new atoms together weigh slightly less than the original uranium atom. This difference in weight — or mass — becomes energy in the form of heat. This is the phenomenon predicted 55 years ago by Albert Einstein but only recently put to practical and peaceful use.

Each individual fission gives out only an exceedingly minute quantity of heat; but, since there are many million trillions of fissions taking place within the reactor every second, the total amount of heat developed is large. Small as the energy from each fission is, the amount of weight actually lost is tremendously smaller. In a typical reactor only a few pounds of material will actually be consumed each year, but many millions of kilowatthours of electrical generation will be the result.

Another important aspect of the fission process is that each atom as it splits releases two or three free neutrons. Neutrons are one of the basic building blocks of nature. All material — whether animal, vegetable or mineral — is made up of neutrons in combination with other particles called protons and electrons.

The neutrons released during the fission of one uranium atom move through the reactor core until they meet another atom of uranium, whereupon another fission is triggered. The process is thereby made continuous; each generation of fissions releasing enough neutrons to give rise to a new generation. This sequence continues as long as the reactor is in operation and is referred to as a chain reaction.

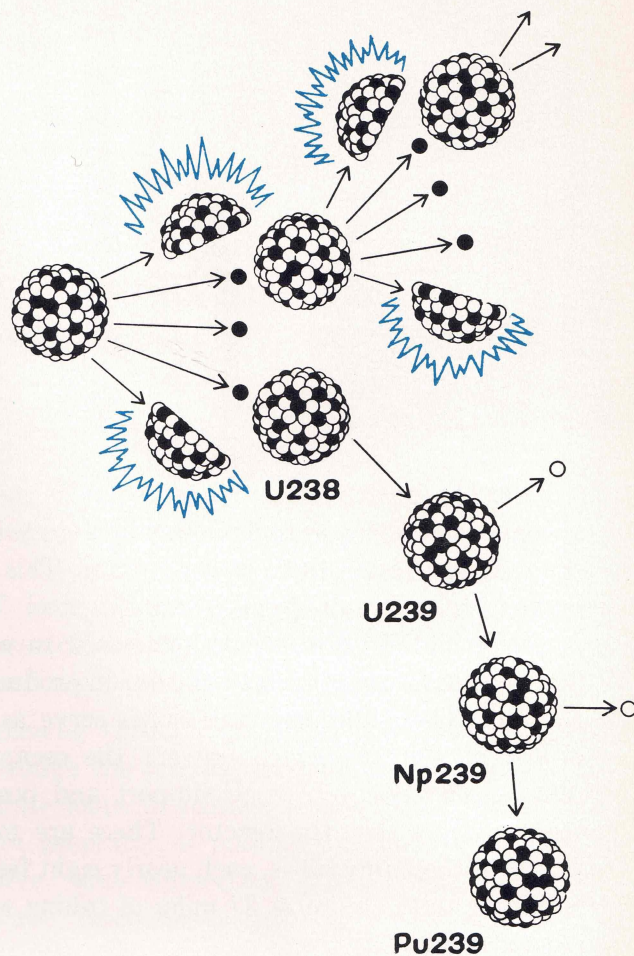
Uranium atoms exist in several different forms, called isotopes, one of which is much more readily fissioned than the others. This fissionable isotope makes up less than one per cent of the uranium existing naturally. In order to provide enough of this fissionable uranium, known as uranium-235, in most reactors the proportion must be increased. In the Yankee reactor the uranium is enriched so that the uranium-235 content is 3.4 per cent.

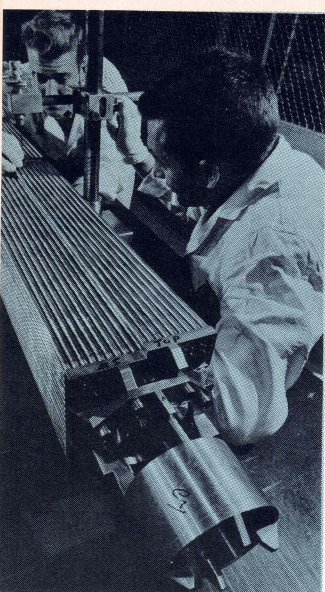
The chain reaction is maintained if only one of the two or three neutrons given off during each fission finds another atom of uranium and causes another fission. The other neutrons are absorbed by atoms of the other materials in the reactor or in the shielding around it. Some of these neutrons strike atoms of the type of uranium which is normally not fissionable and another very important process takes place. The atoms of uranium-238 are transmuted into even heavier atoms of an element which does not exist naturally anywhere in the world. This new material — the alchemists' goal, at last — is called plutonium. Its most important characteristic is that it is fissionable.

Some 14 per cent of the power generated at Yankee comes from fissions taking place in plutonium atoms that have been formed in the fuel during operation. When the fuel is removed, it contains additional plutonium which is eventually processed to provide fuel for other reactors or weapons material for military purposes. The amount of extra plutonium formed in this reactor will equal in weight about half the amount of the uranium-235 consumed.

The fuel in the Yankee reactor is in the form of small pellets of an oxide of uranium called UO_2 . This material was chosen because it is the form of uranium least affected by conditions within the reactor. It is not appreciably damaged by the fission process, nor by reactor temperatures, and is also practically unaffected by exposure to hot water. Since reactor fuel is expensive, the longer it can remain in the reactor producing heat, the better.

The pellets of UO_2 are formed individually under tremendous pressure in automatic hydraulic presses and are then heated to almost $3,000^\circ\text{F}$. The heating process further reduces their volume and produces a dense hard material almost like porcelain. The core of the Yankee reactor contains over 3,400,000 of these pellets.



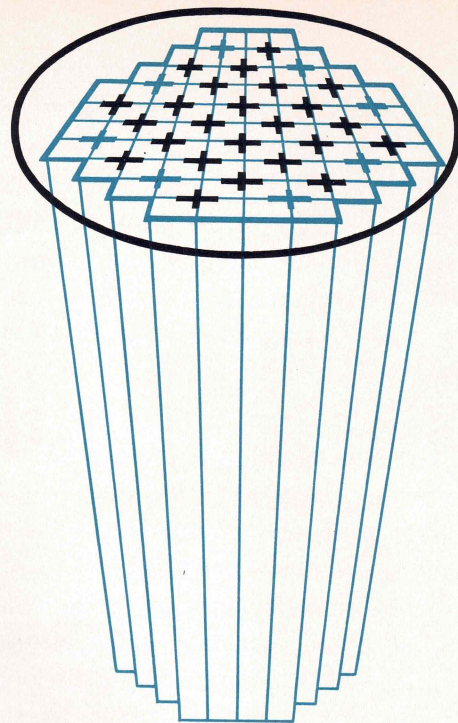


How the Reactor Works (continued)

The cylindrical surface of the pellets is ground very accurately to size so as to fit closely into the tubes which are used to contain them in the reactor. This tubing is made of special high-strength stainless steel. The great majority of the radioactivity generated in an atomic power plant is represented by the fission products within the fuel. These stainless steel tubes serve as the first of several barriers which prevent the escape of this radioactivity, as well as to support and position the fuel pellets within the reactor. There are more than 23,000 of these fuel tubes, each nearly eight feet long — making a total of almost 37 miles of tubing within the reactor core.

Each of these tubes is filled with 150 fuel pellets, sealed at both ends, and brazed into bundles or sub-assemblies. Small tubular spacers, called ferrules, separate each tube from its neighbor. Nine of these subassemblies are assembled into larger bundles containing over 300 rods and are held together by welded steel straps. These groups of nine subassemblies are called fuel assemblies. The reactor core is made up of 76 such units, arranged so as to approximate a cylinder eight feet high and six feet in diameter. At both ends of each fuel assembly, fixtures are provided to support the assembly within the reactor. These fixtures also are used for handling when inserting or removing a fuel assembly.

During reactor operation, water is circulated upward through the reactor core. Since every fuel tube is slightly separated from those next to it, the water flows freely around and past each of them. The water serves two essential purposes: the first being to slow



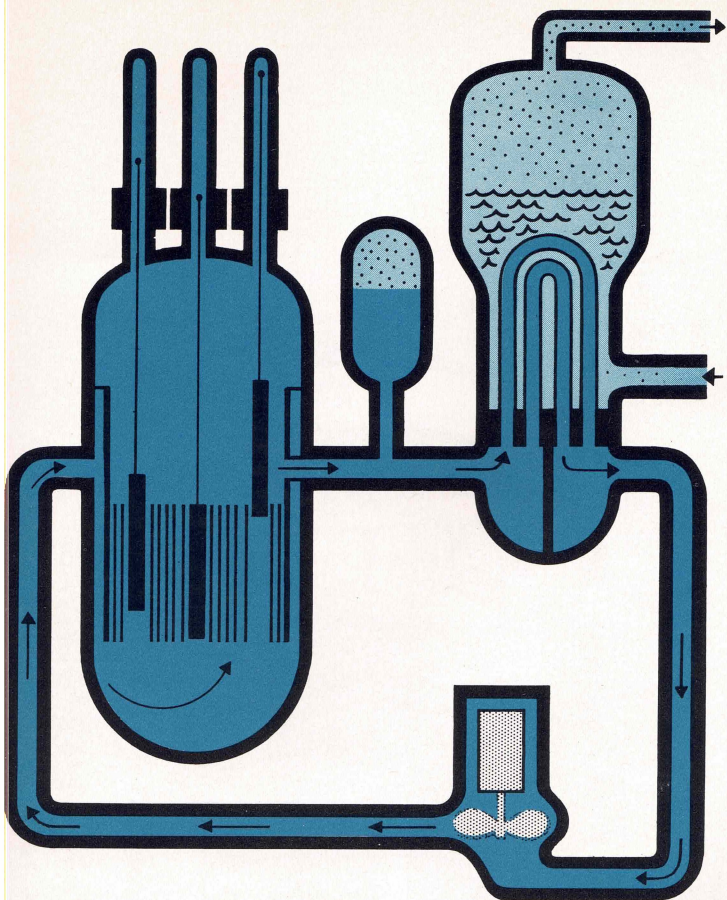
down the neutrons which are moving through the core, and the second, to remove and carry away the heat being generated within the fuel.

The neutrons given off as an atom fissions move too rapidly to be efficient in triggering additional fissions. The light hydrogen atoms in ordinary water provide a cushioning effect which quickly slows the neutrons to a speed at which the probability of additional fissioning is much greater. Without this slowing-down effect, or moderation, the chain reaction could not be maintained.

The heat, which is developed when atoms within the fuel fission, is conducted to the surface of the pellets, through the stainless steel tube, and carried away by the water circulating through the core. This water is pressurized to 2,000 pounds per square inch in order to prevent the formation of steam within the reactor — hence the name, pressurized water reactor.

One of the advantages of the pressurized water reactor is its very strong inherent tendency to be self-regulating. If the temperature of the core rises, the water becomes less dense and therefore less effective as a moderator. This has the effect of reducing the number of fissions taking place and therefore the amount of heat being developed. In the simplest terms, then, it is impossible for this type of reactor to run away.

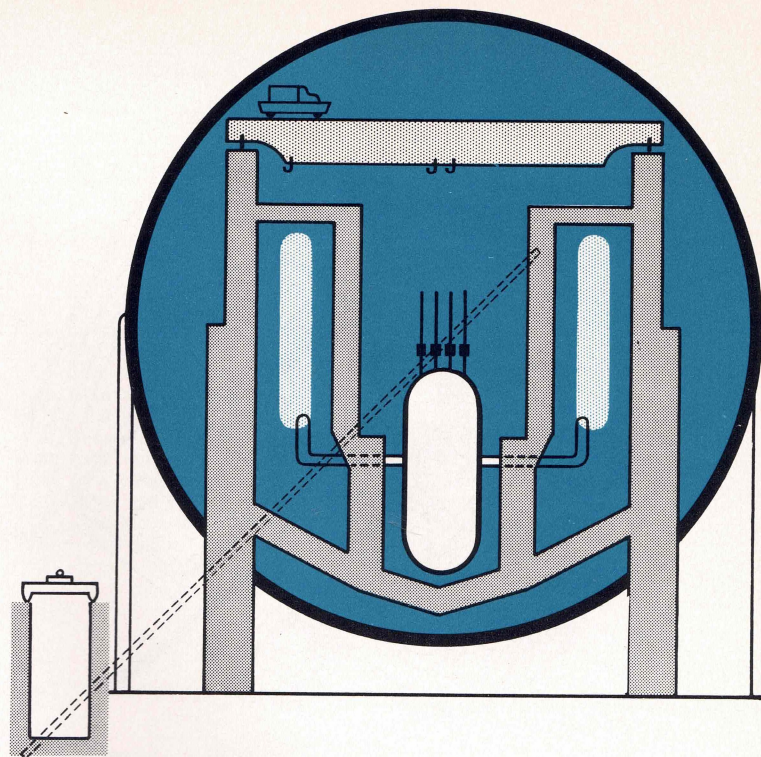
Also an essential part of the reactor core are the 24 control rods. These are cross-shaped so as to slide through spaces left between the square fuel assemblies



for this purpose. The control rods are made of an alloy of silver, indium and cadmium which is highly effective as a neutron absorber. By withdrawing the control rods from the core, fewer neutrons are absorbed, more are available to cause fissioning and the reactor power increases. When the control rods are inserted more neutrons are absorbed until finally the chain reaction dies out and the reactor is shut down. Normally, the control rods are moved in and out quite slowly, but at any indication of trouble they are automatically released and fall into the core by gravity — an operation technically known as a scram.

In this reactor, additional control for cold shut-down is provided by adding boric acid solution to the water in the reactor. The boric acid acts as a neutron absorber and prevents any possibility of a chain reaction as the reactor is cooled down from operating temperature to room temperature.

The reactor core is contained within a cylindrical steel pressure vessel, whose walls are eight inches thick. This reactor vessel is $31\frac{1}{2}$ feet high and over 10 feet in diameter. Within the vessel are the necessary internals to direct the flowing main coolant and to sup-

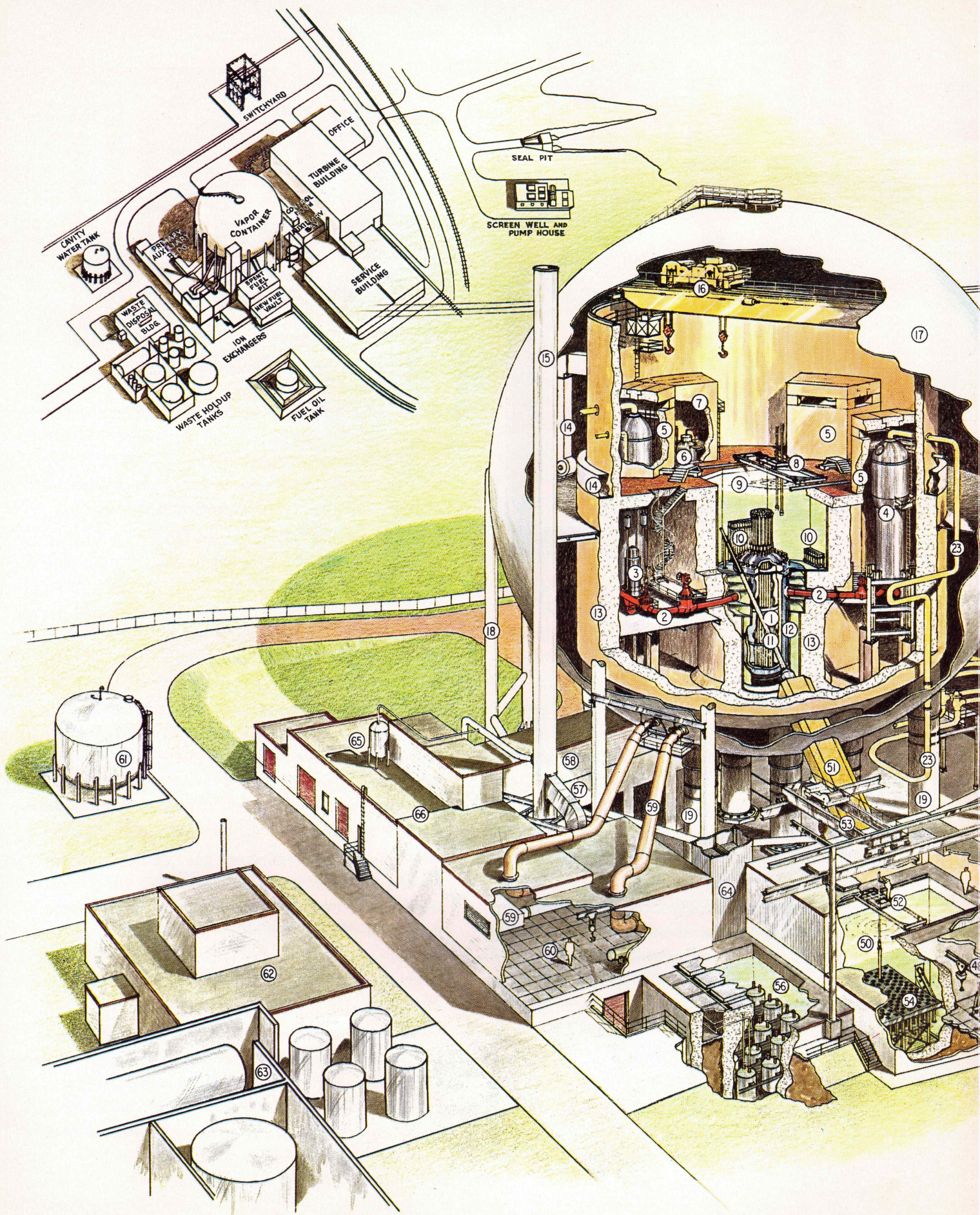


port the reactor core and control rods. Mounted on the reactor head are the 24 control rod drives.

After passing through the core, the heated water travels through the primary system, which consists of four separate loops in parallel. Each loop is made up of a steam generator, a pump, two shutoff valves, a check valve, and connecting piping. The primary system water circulates continuously through these loops, removing heat generated in the reactor, carrying it to the steam generators where it is transferred to the secondary system, and then returning to the reactor to repeat the process. The pump in each loop circulates over 23,000 gallons every minute which means that each drop of water in the primary system makes more than four round trips during that time.

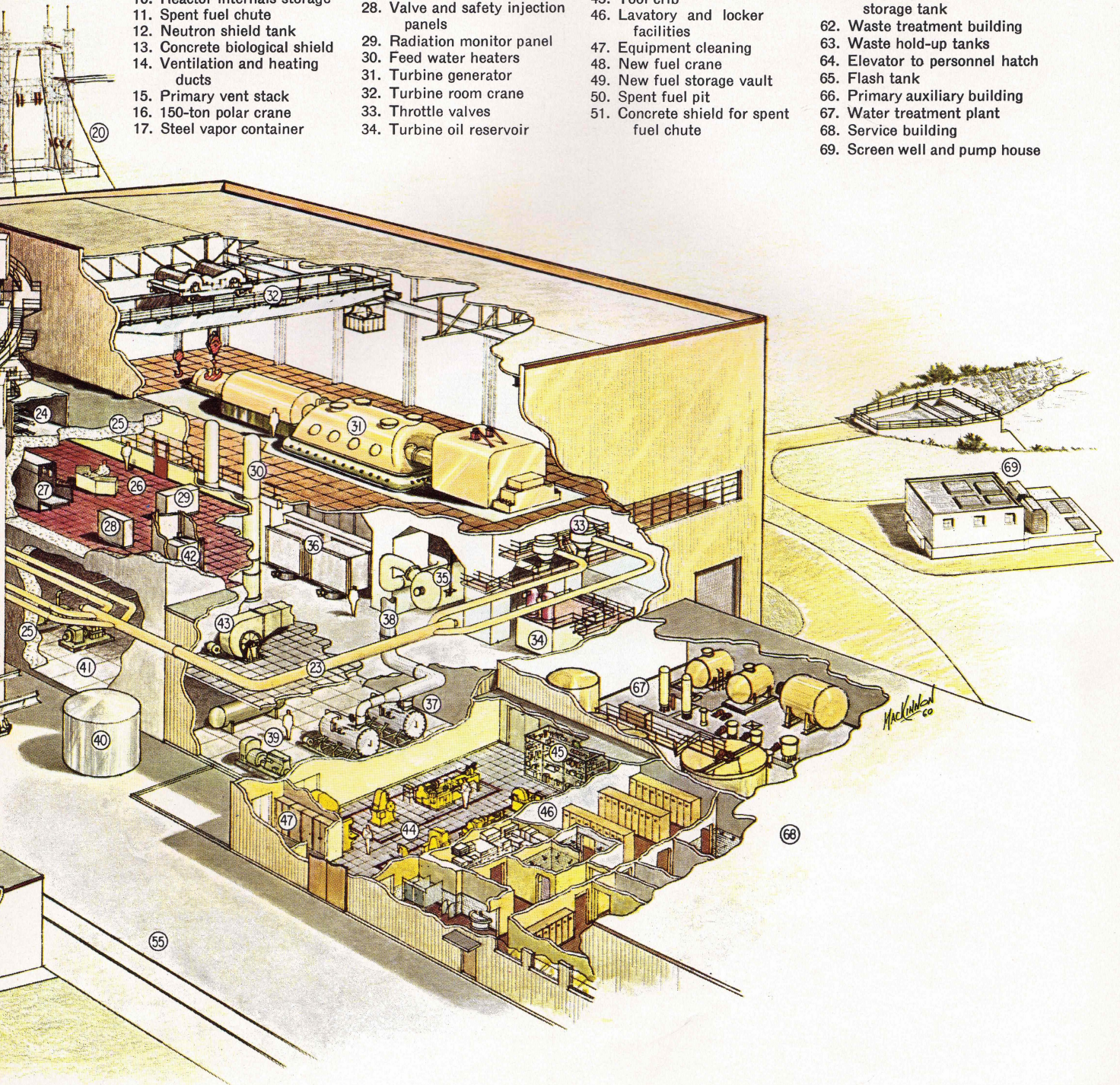
In the steam generators the primary system water travels inside of stainless steel tubes which separate it from the secondary system water on the outside of the tubes. The heat passing through these tubes from the primary water boils the cooler, lower-pressure secondary water, transforming it into steam.

From this point on, the basic Yankee plant resembles closely any conventional steam-electric plant. The steam from the steam generators is used to drive a turbine which turns an electric generator. After passing through the turbine, the steam is condensed and the resulting water is pumped back to the steam generator, thereby completing the circuit in the secondary system.

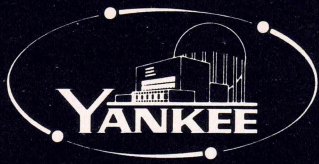


YANKEE ATOMIC ELECTRIC COMPANY

1. Reactor core
2. Main coolant loop
3. Main coolant pump
4. Steam generator
5. Steam generator compartment
6. Pressurizer
7. Pressurizer compartment
8. Fuel manipulator crane
9. Steel-lined shield tank cavity—water filled at fuel change
10. Reactor internals storage
11. Spent fuel chute
12. Neutron shield tank
13. Concrete biological shield
14. Ventilation and heating ducts
15. Primary vent stack
16. 150-ton polar crane
17. Steel vapor container
18. Steel vapor container columns
19. Steel encased concrete columns
20. Switchyard structure
21. Electrical penetrations
22. Walkways
23. Main steam piping
24. Cable tray room
25. Concrete shielding
26. Control room
27. Main control board
28. Valve and safety injection panels
29. Radiation monitor panel
30. Feed water heaters
31. Turbine generator
32. Turbine room crane
33. Throttle valves
34. Turbine oil reservoir
35. Interstage moisture separator
36. Main condensers
37. Heating boilers
38. Heating boiler stack
39. Engine driven electric generator set
40. Demineralized water tank
41. Pump and compressor bay
42. Control room elevator
43. Ventilation fan and ducts
44. Machine shop
45. Tool crib
46. Lavatory and locker facilities
47. Equipment cleaning
48. New fuel crane
49. New fuel storage vault
50. Spent fuel pit
51. Concrete shield for spent fuel chute
52. Spent fuel manipulator crane
53. Work area crane
54. Spent fuel storage
55. Spur tracks
56. Ion exchangers
57. Shielded radioactive pipe tunnel
58. Non-radioactive pipe tunnel
59. Purge ducts
60. Ventilation room
61. Safety injection—water storage tank
62. Waste treatment building
63. Waste hold-up tanks
64. Elevator to personnel hatch
65. Flash tank
66. Primary auxiliary building
67. Water treatment plant
68. Service building
69. Screen well and pump house



This cutaway drawing shows the interior of the Yankee plant and the arrangement of all major equipment. The diagram at upper left identifies the various buildings at the site.



The Plant In Progress

March 1958—Construction forces move in

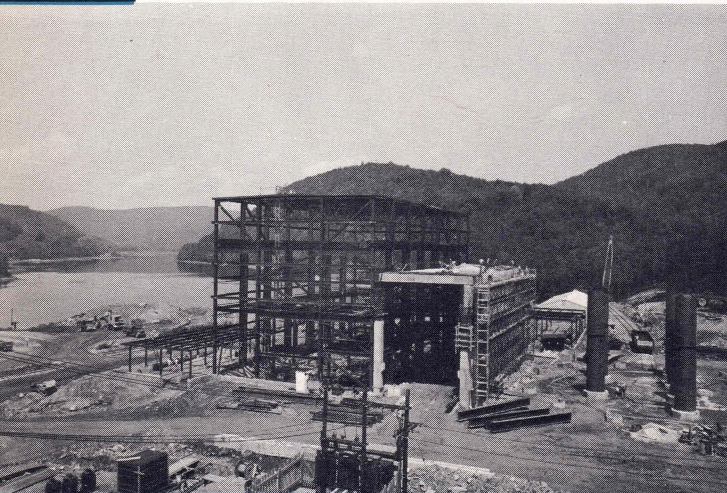


1

June 1958—Concrete foundations

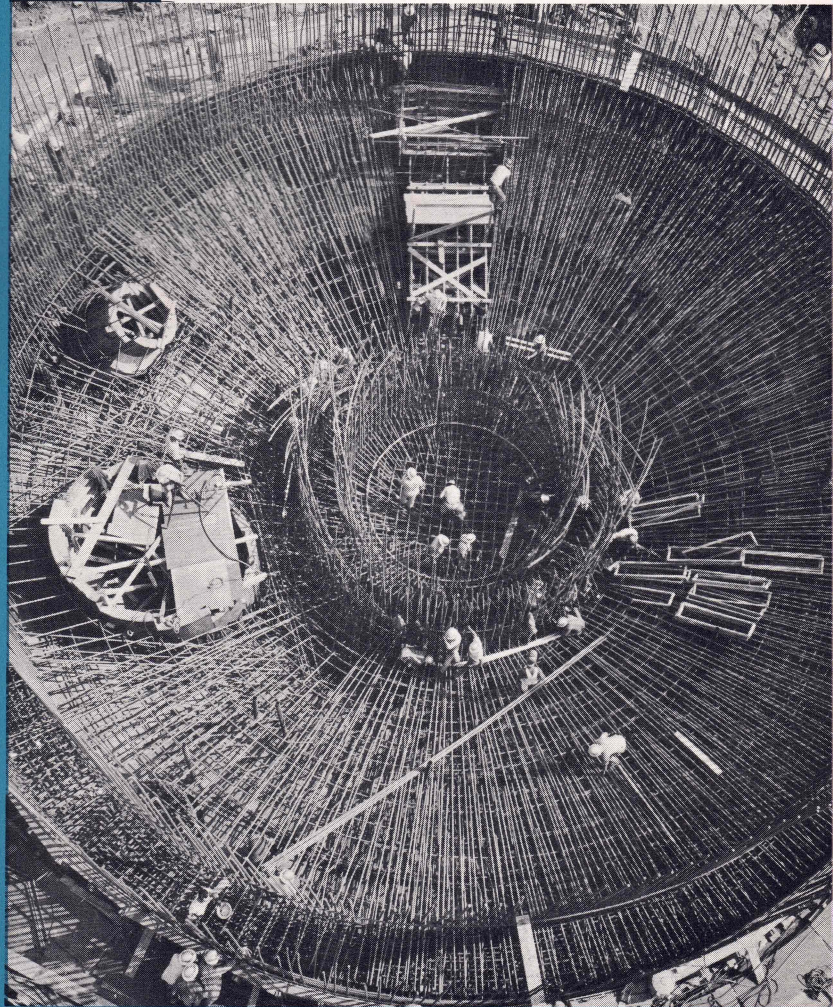
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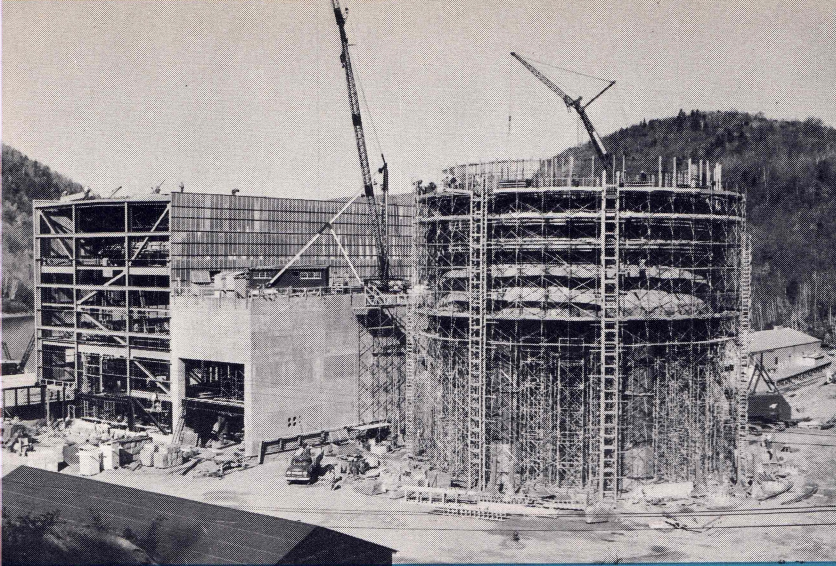
July 1958—Turbine building, structural steel and columns for reactor structure



3

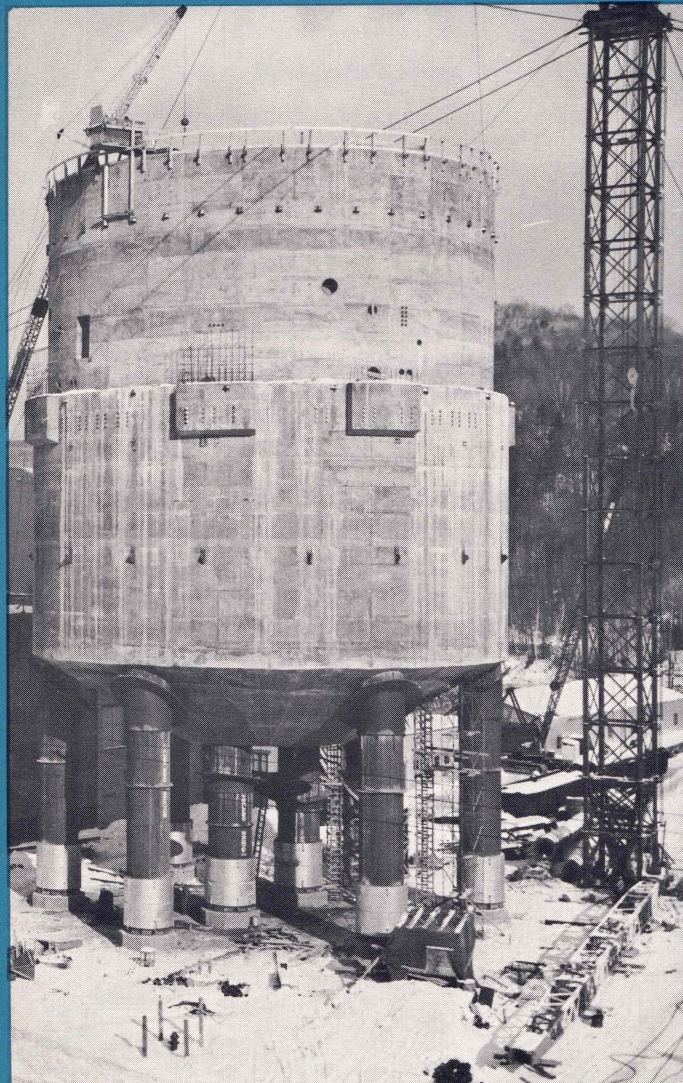
September 1958—Reinforcing steel for reactor structure





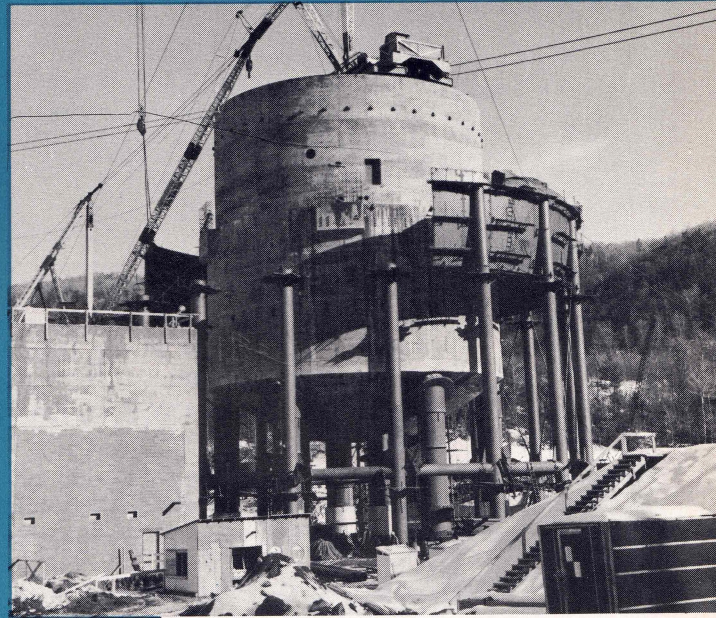
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October 1958—Temporary scaffolding for reactor structure



5

December 1958—Concrete reactor structure

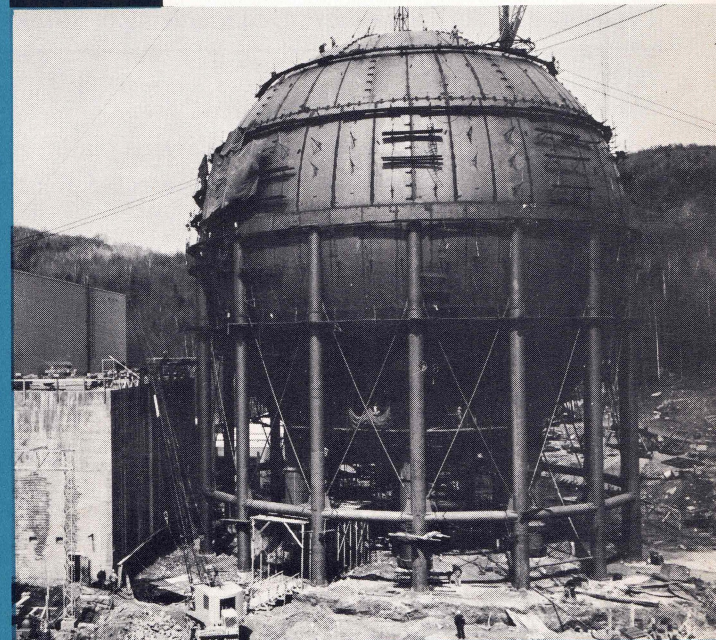


6

January 1959—First plates for steel sphere

7

May 1959—Completion of steel sphere



June 1960—Construction and testing completed

Chronology

1954

- August 30* President Eisenhower signed the amended Atomic Energy Act into law, permitting private ownership of atomic facilities.
- August 31* Representatives from New England utilities agreed to form an atomic power company.
- September 16* First meeting of Yankee directors.

1955

- March 30* Yankee submitted its original proposal under the AEC's new Power Demonstration Reactor Program.
- August 22* Revised proposal to AEC for a 134,000-kw plant.
- November 30* Completed purchase of 2,000 acres in Rowe, Mass. as site for Yankee plant.

1956

- June 6* Yankee signed first contract with AEC under PDRP.
- July 1* Westinghouse and Stone & Webster authorized to proceed on plant engineering and design.
- September 4* Land clearing operation and background radiation monitoring begun at site in Rowe.

1957

- May 28* First orders placed for materials and equipment.
- October 8 & 24* AEC held public hearings on Yankee application for permit to build.
- November 4* Construction permit granted by the AEC.
- December 19* Yankee arranged financing of \$57,000,000.

1958

- March 17* Excavation begun at site.
- April 11* First concrete foundations placed.
- June 20* First structural steel erected for turbine hall.
- September 26* The largest concrete placement — 1,000 cubic-yard continuous pour — made in saucer-like base of internal structure for reactor. Concrete weighed 2,000 tons — reinforcing steel 100 tons.
- December 2* Erection of 125-foot diameter steel sphere begun.

1959

- April 24* 160-ton generator stator, first piece of major equipment, arrived at site.
- June 12* Securities and Exchange Commission approved permanent financing plan.
- September 30* Start of on-site personnel training program.
- October 31* Initial shipment of five fuel assemblies arrived.

1960

- February 7* Largest single piece of equipment, 165-ton reactor vessel arrived at site.
- March 31* Hydrostatic tests of primary system.
- May 25* AEC held hearing on Yankee request for an operating license.
- July 9* Operating license issued by AEC.
- July 15* Fuel loading started.
- July 26* Fuel loading completed.
- August 19* 8:19 p.m. Yankee went critical.
- November 10* First generation of electricity.

1961

- January 17* Plant attained full provisional license power — 120,000 kw.
- February 8* 500-hour run at full power completed.
- June 8* Final AEC License Hearing.
- June 23* AEC grants 40-year license.
- June 30* Yankee achieves 152,500 kw peak generation.
- July 1* Plant placed in commercial operation.
- August* 100,000,000 kwh generated during the month.
- December 31* Yankee supplied 4 per cent of New England area total energy requirements. Gross generation to date 961,347,000 kwh. Use factor, 70 per cent plus.

1962

- January 12* Yankee reached 1,000,000,000 kwh.
- May 18* End of 147-day continuous run to give total generation of 1,330,000,000 gross kwh; and reactor shut down for refueling.
- June 6* Yankee wins Edison Award.
- September 12* Initial criticality achieved on Core II.
- September 21* Yankee back on the line.
- October 16* Increased output to 170,000 kw.
- December 1962* Use factor 99.28% for the month.

1963

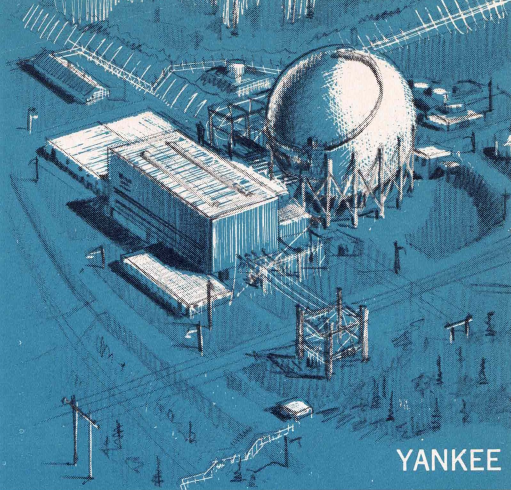
- March 21* Gross generation beyond 2,000,000,000 kilowatthours today.
- September 2* Shutdown for second refueling. Gross Generation 2,536,118,000 kwh and Core II Generation 1,205,597,000 kwh. During entire life of Core II the reactor was maintained continuously at operating temperature and pressure.



NAUTILUS



SHIPPINGPORT



YANKEE

In Perspective

Yankee can be characterized as a third generation plant of the pressurized water type; the first generation having been the reactors used in the *Nautilus* and most other nuclear submarines, and the second generation, the power reactor at Shippingport, Pennsylvania.

The design features of the Yankee reactor are based directly on the knowledge and experience developed in these earlier projects. However, Yankee is no carbon copy of any other plant. Whenever possible the plant design was adapted to the single and specific purpose of generating electricity — as efficiently and as reliably as possible.

The research and development program financed by the Atomic Energy Commission served to implement and prove out this approach. Every aspect of the reactor was investigated either analytically or experimentally or by both means. The program included the general areas of nuclear physics, chemistry, heat transfer, fuel fabrication and design, and the design of various plant systems. A small reactor, called a critical experiment, was assembled and operated using fuel of the Yankee configuration to provide detailed nuclear physics information for core design.

Chronologically, Yankee was the third full-size power reactor to go into operation in the United States. The Shippingport reactor commenced operation in December of 1957 and the Dresden reactor, built for the Commonwealth Edison

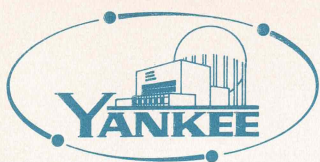
Company and the Nuclear Power Group, began operation in April of 1960. The Dresden reactor is of a different type called a boiling water reactor and is located southwest of Chicago, Illinois. In a boiling water reactor, steam is formed within the reactor itself and goes directly to the turbine, with no intervening heat-exchanger.

First producing power in November of 1960, Yankee became the nation's leading producer of electricity from the atom in February of 1962. It passed the one-billion-kilowatt-hour-milestone with its first core-loading and in this respect, it stands alone. With a peak output of 150,000 kw or over since July, 1961, Yankee was supplying approximately four per cent of the electrical requirements of the New England area.

Because Yankee was a pioneer in the field of atomic power, its progress was followed by many other companies throughout the country and the world. In such a new field where results could have a far-reaching effect, not only in the power industry but in other uses of the atom, Yankee has supplied much information.

Many other atomic power projects are being constructed or planned and all of them have been vitally interested in the accomplishments of Yankee.

Progress is a continuing thing. While the second nuclear core was in use an improved third core was being fabricated, and has now been installed.



People

Yankee's operating organization consists of approximately 70 full-time employees. In building for the future, these people were carefully selected and trained, starting even before there was a formal Yankee organization. Beginning in 1952, men with extensive utility operating experience were sent on loan to various reactor projects throughout the country. The first submarine prototype reactor, the first boiling water reactor experiments, the first breeder reactor, and the Enrico Fermi power reactor being built near Detroit, all had Yankee people participating in their design or operation.

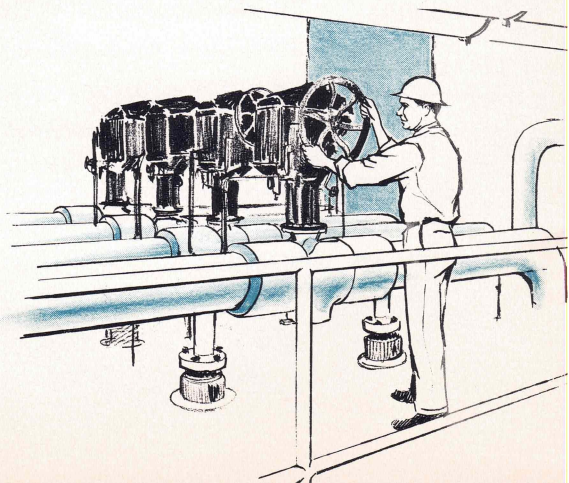
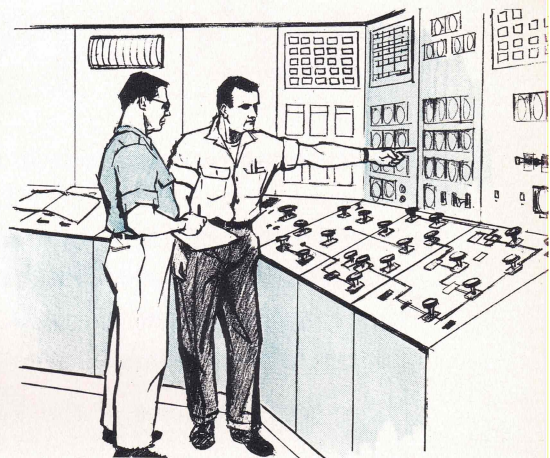
Since that time, Yankee has added to its staff men who have had extensive experience at government installations such as the reactors at Savannah River, South Carolina; Hanford, Washington; West Milton, New York; and Fort Belvoir, Virginia. Most of the remaining people at the Yankee plant have worked previously in the conventional electric generating plants of the sponsoring New England utilities. Throughout the design of the Yankee plant, the engineers and scientists who were to be in charge of its operation worked with Westinghouse and Stone & Webster, and participated directly in each phase of the work.

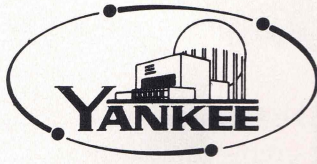
In September of 1959, Yankee began its own training program for operating personnel at the site in Rowe. Basic scientific and engineering courses were covered, as well as intensive instruction in the details of the plant and its operation. The instructors in this program were, for the most part, those members of the plant organization specializing in the particular subject, but on many occasions, experts from other organizations added their technical knowledge.

As the plant neared completion, the emphasis in the training program was shifted from the classroom to the plant itself. Every operator became familiar with each valve, switch, instrument and control throughout the plant. As this knowledge developed, it was augmented and put to practical use as the individual pieces of equipment were checked out and accepted from the construction forces by teams of Yankee operating personnel. Another practical and useful means of plant familiarization was the preparation of detailed operating instructions and check-off lists for the operation of every portion of the plant under all conditions.

As a final requirement, each operator responsible for the operation of the plant must not only be licensed by the State of Massachusetts as an operating engineer, but must also pass both a written and oral examination to qualify for the required Atomic Energy Commission operator's license.

Throughout the project, the Yankee staff was supplemented in a variety of ways. Men of recognized stature in many special fields were retained as consultants. Requirements typical of any utility such as legal, financial, public relations, insurance, right-of-way, drafting and other services were provided by New England Power Service Company, a subsidiary of one of the sponsoring companies. These companies also provided engineers on a loan basis to assist during the design and early operation of the plant.





Economics

Construction and operation of the Yankee plant has done much to clarify the cost of nuclear power. Actual operating experience will, of course, continue to supply answers to many other important cost variables.

This new source of energy has stiff competition. Since the beginning of the century, the efficiency of electrical generation has been improved and improved again. A cost analysis for a new, one-unit fuel-burning plant of a size similar to Yankee and at the same location shows a power cost of around eight mills per kilowatthour. Up to May 18, 1962, the cost of power from Yankee's first core was about $9\frac{1}{2}$ mills per kilowatthour, based on a 20-year plant life and an 80 per cent use factor.

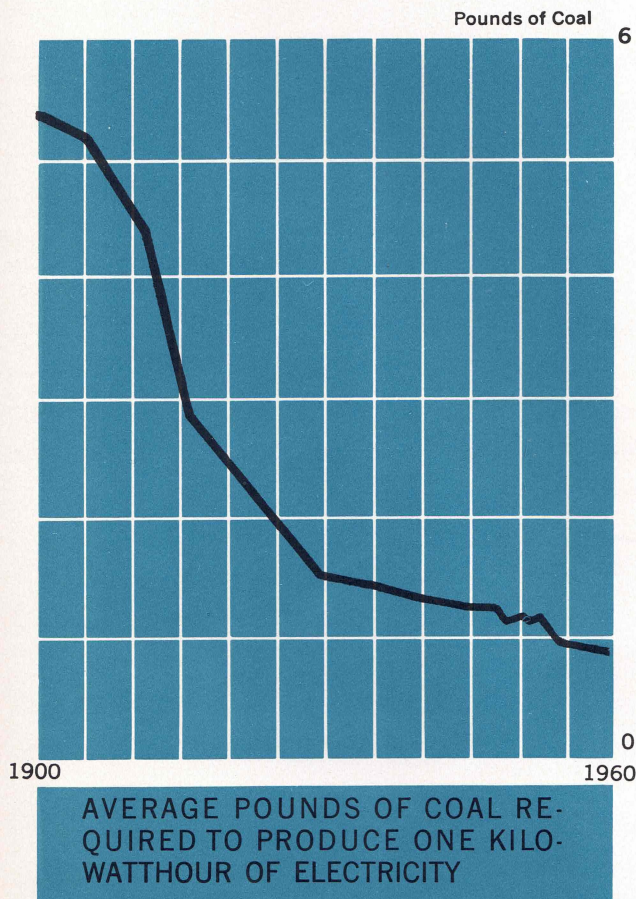
Although one area of Yankee cost has been firmly fixed, that of construction, other areas of cost still cannot be specified exactly and therefore are conservatively evaluated. Such areas include:

1. Rated kilowatt capacity:

Present maximum net output of the plant is 161,000 kilowatts, and an application is pending with the A.E.C. for an increase in the net to 175,000 kilowatts.

2. The annual-hours use:

As was mentioned, the estimate is based on an 80 per cent use factor. Actual operation will demonstrate whether this may be increased, as seems probable, or whether down-time for maintenance will tend to reduce it.



3. The net cost of fuel:

A number of uncertainties are included in this area. The price of uranium is expected to undergo further reduction, as may the credit allowed for plutonium produced. The cost of fabrication can be expected to decrease with competition and volume production, as more reactors come into operation. Although costs of irradiated fuel shipping are now relatively fixed, costs of fuel processing remain only within rather wide limits.

4. Operating costs:

The annual cost of operation and maintenance is approximately \$6,500,000. This represents about 6 mills per kilowatthour based on an output of 1.1 billion kilowatthours per year.

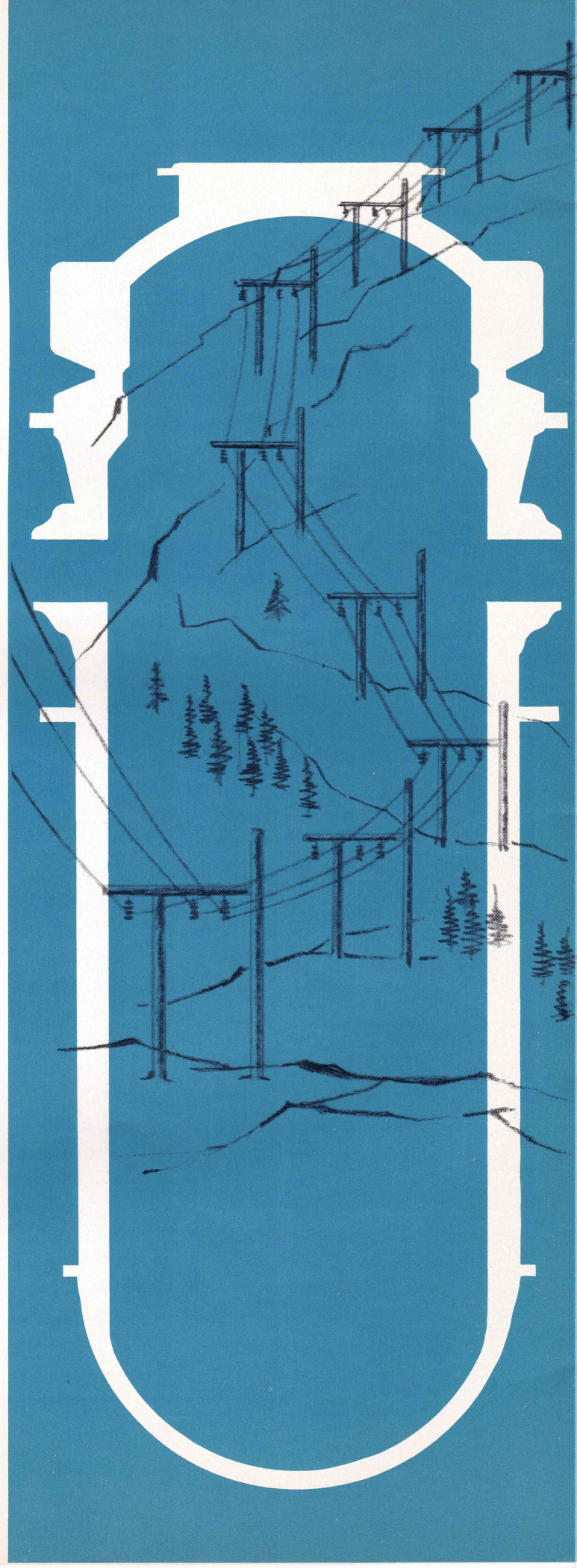
Again, only actual operating experience can provide a real check on the present estimates.

5. The life of a fuel-loading:

Life of Yankee's first core is now known and the second core was a duplicate of it. Data collected during their operation made an improved third core possible and has given greater assurance for future core designs which will provide longer life and improved performance.

To summarize, it is only reasonable to assume that the cost of Yankee power, and of nuclear power in general, will be reduced as additional knowledge and experience take effect. We believe that this reduction may be substantial. Conventional plants, on the other hand, are being constantly improved but they cannot be expected to make such substantial improvements and are very sensitive to the price of fuel.

The use of electricity is increasing at an average rate of over seven per cent each year — a rate that will more than triple present use before 1980. It is inevitable, as this growth continues and as supplies of coal and oil dwindle, that the cost of fossil fuel must increase. The only question, then, is at what point the decreasing cost of nuclear power will become less than the increasing cost of power from fossil-fuel plants. Estimates now range from "less than 10 years" to "more than 20 years". The operation of the Yankee plant can go a long way toward providing the answer to this question.





Commendations

Since the conception of the Yankee plant in 1954 through its present operation, the Yankee project has attracted wide national attention. The awareness of many outside the Yankee organization to the noteworthy accomplishments of the Company have become evident from the list of awards the project has received:



THE EDISON AWARD

The top utility award in the country was received by Yankee President William Webster at the 30th Annual Edison Electric Institute Convention in 1962.

The Company was cited for "the completion of the plant well ahead of schedule, and at a capital cost 23 per cent below the estimate, for producing its first billion kilowatthours at a fuel cost of 2.8 mills per kilowatthour, compared to a fossil-fuel cost of 4.2 mills in the territory served; financing the construction with the private funds of ten cooperating electric companies serving the region; having the nuclear steam generator available for load 96 per cent of the time during the first core and at a 70 per cent load factor; developing a staff of well-trained personnel who did the fuel loading."

- ★ The United States Atomic Energy Commission termed the plant "the nuclear success story of 1961" in its annual report to the Congress, made in 1962.
- ★ Top prize was given to the movie, "Pioneering With Power" produced by the company, at the International Film Festival in Rome, Italy in June 1961.
- ★ The American Society of Civil Engineers named the plant as one of 11 finalists for its award as the outstanding construction project of 1961.

Victor Riesel, syndicated columnist specializing in the labor field, cited the construction of Yankee as an outstanding example of what can be accomplished by advance planning between labor and management. Not one day was lost because of labor-management quarrels. There was not even a serious dispute.

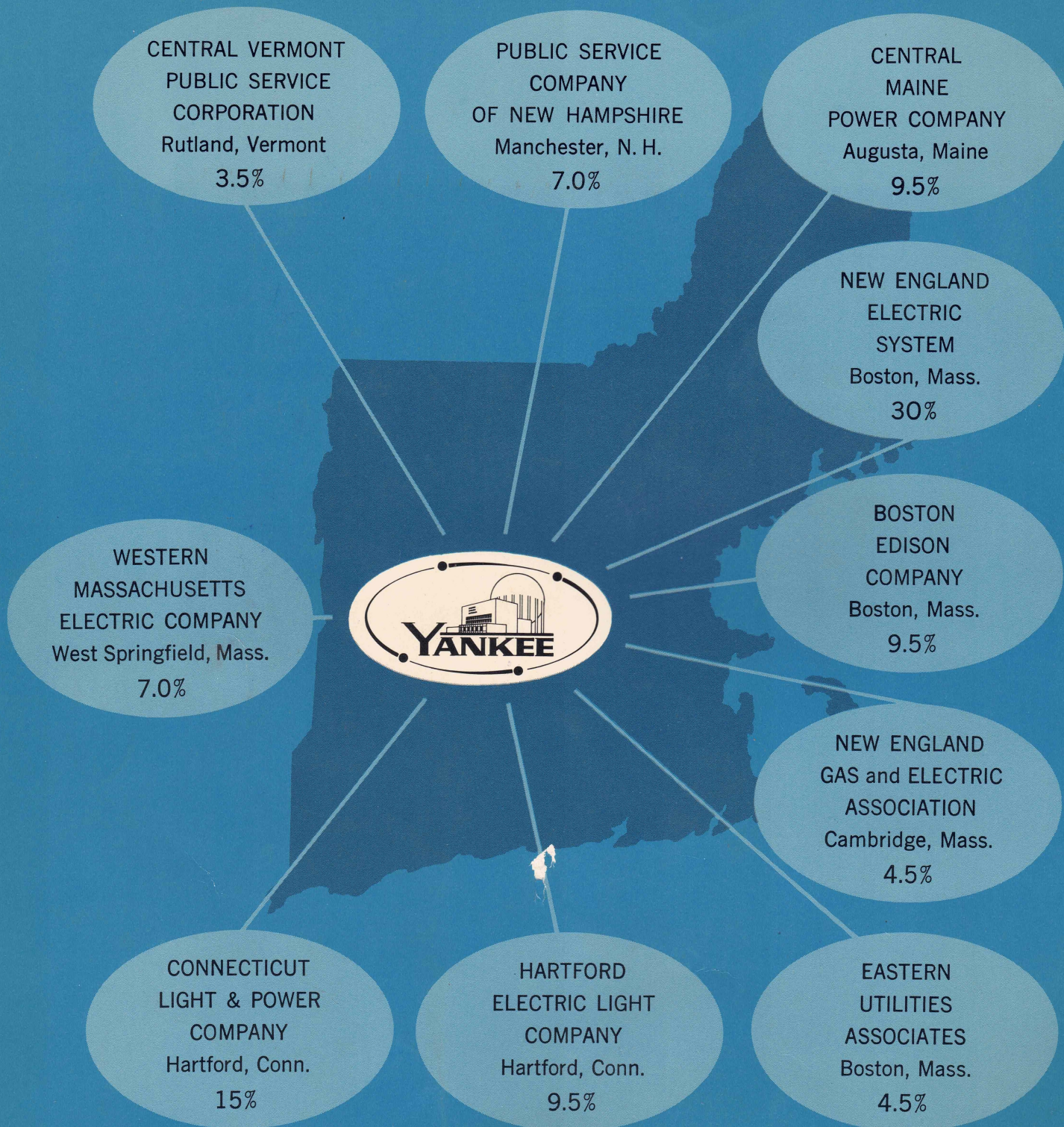
In addition to these major awards the Yankee project has been the recipient of national publicity, has been cited on the floors of the United States House of Representatives and Senate and by a number of state and federal commissions and officials.

THE BEGINNING, NOT THE END

The Yankee story is only the beginning of atomic power development in the New England region, rather than the end. Already plans are well underway for the construction of a second, and much larger atomic installation at Haddam Point, Connecticut to be built by substantially the same utilities as for Yankee I.

Connecticut Yankee Atomic Power Company's plant will have a reactor of the pressurized water type, generally similar to Yankee Atomic's but three times as large in output. The plant, to be completed in 1967, will produce over 500,000 kilowatts of power at a cost substantially competitive with the most modern steam generating stations in this region.

Additionally plans are already in the formative stage for more atomic power plants, for Yankee at Rowe has proven that New England's future power supply is in the atom.



SPONSOR COMPANIES AND PERCENTAGES OF YANKEE OWNED

TREND OF AVERAGE USE AND COST OF ELECTRICITY IN THE NEW ENGLAND HOME

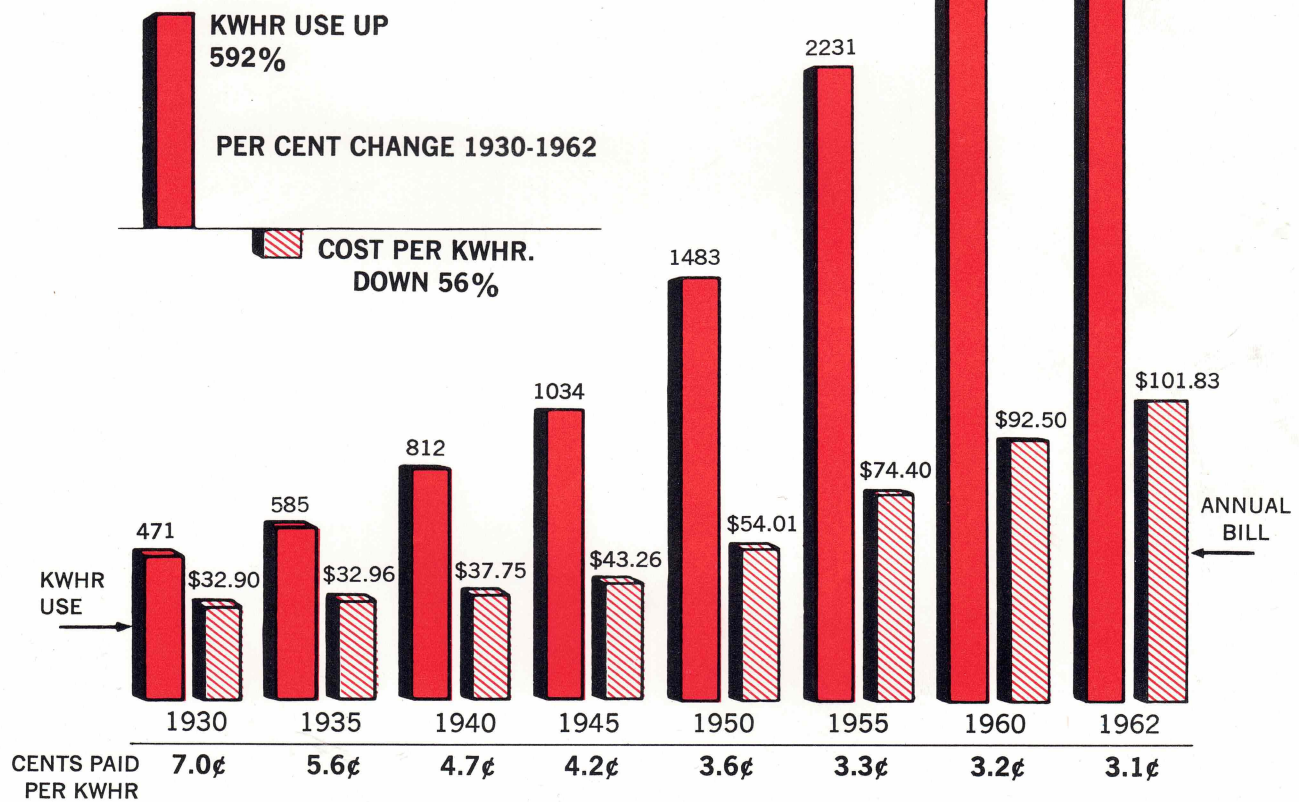
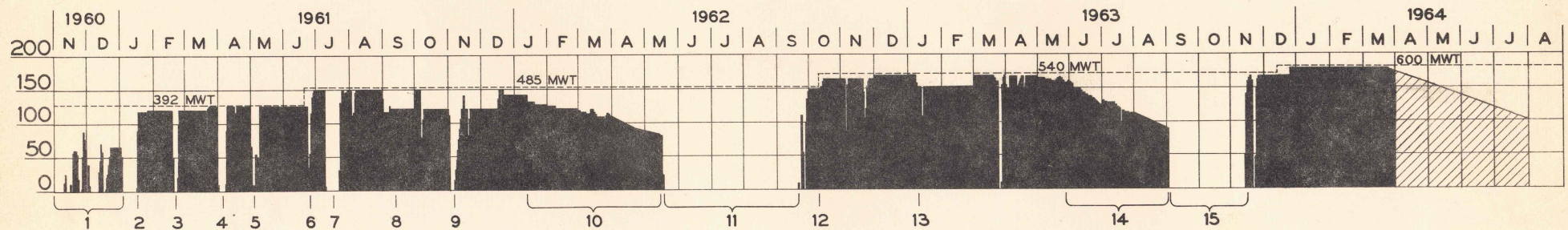


FIGURE 1.

YANKEE ATOMIC ELECTRIC COMPANY
AVERAGE DAILY GENERATION
GROSS MEGAWATTS



- | | |
|--|-------------------------------|
| 1. INITIAL TEST OPERATION | 8. BORON TEST |
| 2. TURBINE VIBRATION CORRECTED | 9. SCHEDULED PHYSICS TESTING |
| 3. VALVE REPAIRS | 10. "STRETCH-OUT" |
| 4. SCHEDULED PHYSICS TESTING | 11. REFUELING NO. 1 |
| 5. MODIFIED PRESSURIZER INSTRUMENTATION | 12. POWER INCREASE TO 540 MWT |
| 6. POWER INCREASE TO 485 MWT | 13. BORON TEST |
| 7. SCHEDULED PHYSICS TESTING; TURBINE GOVERNOR | 14. "STRETCH-OUT" |
| | 15. REFUELING NO. 2 |

YANKEE STATISTICS

	CORE I	CORE II	TOTAL
GROSS GENERATION - KWH	1,330,521,000	1,205,597,000	2,536,118,000
STA. SERVICE - KWH	107,560,431	79,734,618	187,295,049
NET OUTPUT - KWH	1,222,960,569	1,125,862,382	2,348,822,951
AVG. BURNUP - MWD/MT	8,470	7,866	--
BURNUP - TWO CORE I ASSEMBLIES - MWD/MT	12,300	10,172	22,248
HOURS REACTOR CRITICAL	13,247	8,300	21,547
USE FACTOR - % (INCL. REFUELING)	58.4	72.5	64.0